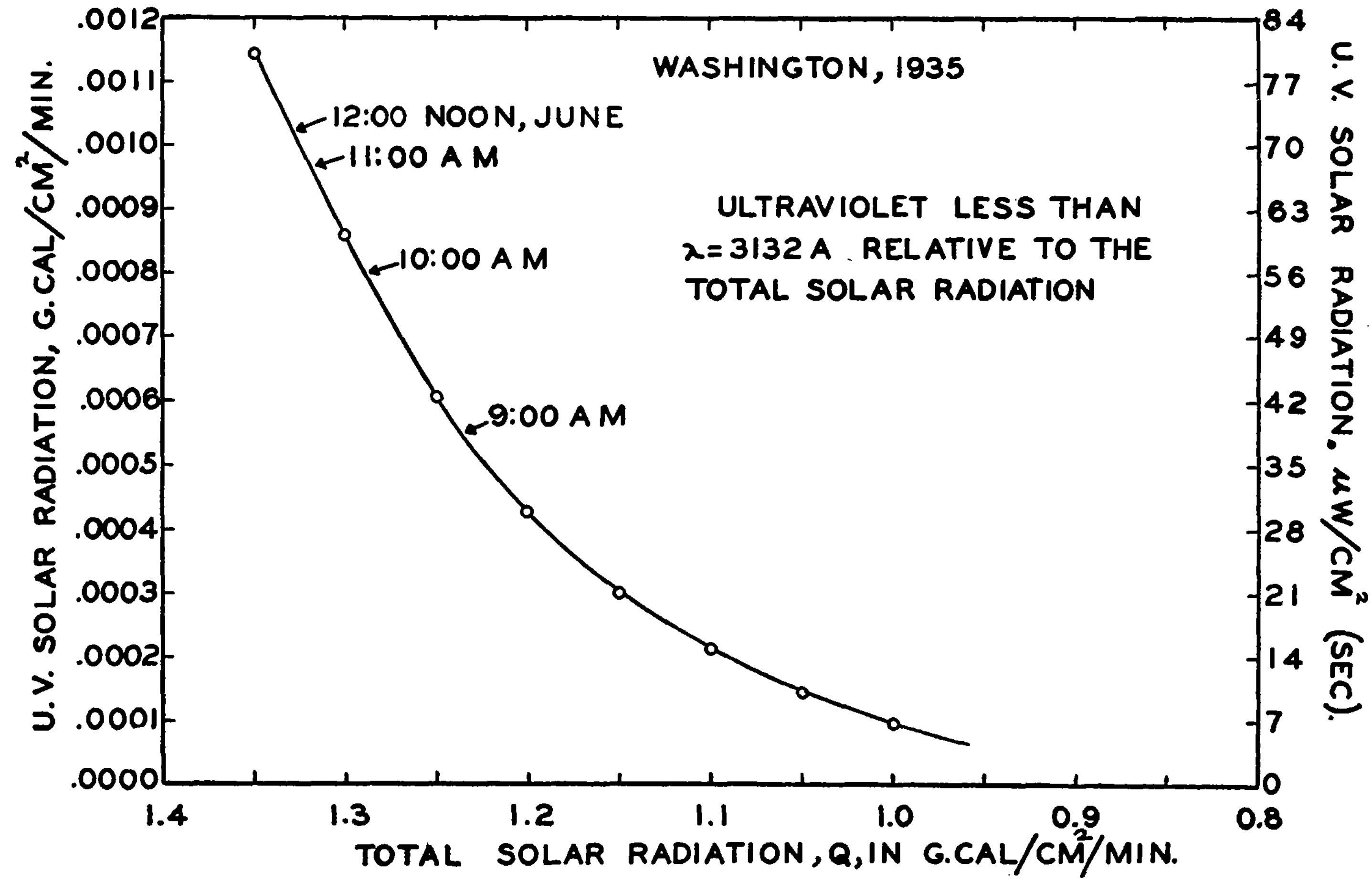

FIGURE 3.

of Standards, Washington, D. C.; and abstracts of this procedure are published in recent issues of Strahlentherapie and of the Annales d'Actinologie.

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(2) W. W. Coblentz, R. Stair, and J. M. Hogue, B. S. J. Res., *8*, 759 (1932), R. P. 450. This paper gives a description of tests made with a balanced thermocouple and filter radiometer as a standard ultra-violet dosage intensity meter.

(3) W. W. Coblentz and R. Stair. Jr. Res. Nat. Bur. Stds., *12*, 231, (1934), R. P. 647. A description is given of the construction and performance of a portable ultra-violet meter, consisting of a balanced amplifier (in the form of a Wheatstone bridge) photoelectric cell and microammeter. A novelty in this device is a means of unbalancing the bridge and thereby testing its sensitivity at any moment—an important item apparently overlooked by recent experimenters in this field.

(4) W. W. Coblentz and R. Stair, J. Res. N. B. S., *16*, p. 315 (1936), R. P. 877. The evaluation of ultra-violet solar radiation at sea-level, in the Tropics, and in midlatitude, also measurements at high altitudes, are described. A comparison of the measurements with the differential thermopile and filters (1), (2), and with the photoelectric cell and filter method (3) is described.

(5) W. W. Coblentz and R. Stair, B. S. J. Res., *11*, 79 (1933) R. P. 578. Data are given on the standards of thermal radiation first issued in 1914, and since then maintained by the Nat. Bur. Standards.

(6) W. W. Coblentz and R. Stair, J. Res. N. B. S., *16*, 83 (1936) R. P. 858. A description is given of a standard source of ultraviolet radiation for calibrating photoelectric dosage intensity meters. In the first-described model a quartz-mercury arc, with one electrode of mercury, was used. In the most recent set-up the source is a newly developed quartz-mercury vapor lamp in which both electrodes are of activated metal and in which there is only a globule of mercury which is completely vaporized. Hence there is no change in density of the mercury vapor with change in temperature.

THE GEOMETRICAL THEORY OF HALOS—I

By EDGAR W. WOOLARD

[Weather Bureau, Washington, D. C., November 1936]

Sundogs or mock suns, and colored rings around the sun or the moon, are more or less familiar to everyone; they have been regarded popularly as indications of the coming weather ever since the time of the Chaldeans. These phenomena may be divided into two general classes, on the basis of their physical origin:

First, when light from the sun or the moon shines through a thin cloud of *water droplets* in the earth's atmosphere, the light which passes *between* the droplets is *diffracted;* and, as a result, under appropriate conditions the luminary is observed to be surrounded by one or more series of partial or complete rings, usually small—only a few degrees in radius—and more or less distinctly colored. The colors are arranged in prismatic sequence, *with the red farthest from the source of light.* This optical phenomenon is known to the meteorologist as a *corona*—lunar or solar, as the case may be.

If, however, the cloud consists of *ice crystals*, the light which passes *through* the crystals is *refracted;* and, as a result, a class of optical meteors known as *halos* often appear, examples of which are the *large* prismatically colored ring (about 22° in radius) which is quite frequently present around the sun or the moon, and the mock suns occasionally seen to the left and right of the sun. These (like all halos that show colors) *have the red nearest the luminary;* in addition, white arcs are sometimes produced in various parts of the sky by reflection—external or total internal—from the surfaces of the crystals.

A halo and a corona have never with certainty been seen simultaneously on the same cloud; and theoretical considerations indicate that diffraction by a cloud of ice crystals cannot produce a corona.[1] The simultaneous appearance of halos and coronas on *different clouds* has been witnessed, however. Under-cooled water droplets are common in the earth's atmosphere; and hence a cloud may be at a temperature below the freezing point, and yet produce a corona.

Among the innumerable crystalline forms produced by the condensation of water vapor in the atmosphere at temperatures below freezing, as illustrated, e. g., in frostwork and by snowflakes, there are two or three quite simple ones from which all the others may be built up, viz, hexagonal columns with or without pyramidal caps (complete or truncated) and hexagonal plates; the columns are sometimes capped with plates, and the pyramids may occur unattached to columns. These elementary forms are frequently observed in snow and frost at low temperatures, especially in polar regions; they often are present in the atmosphere when a halo display is witnessed, and there is every reason to believe that it is some one or more of them, or simple combinations thereof, which ordinarily produce halos, and not the complicated crystal groups and patterns shown in general by snowflakes—in fact, the majority of authenticated halos do not require anything more complicated than a simple hexagonal right prism (column or plate). Some of the finest halo displays have occurred with a cloudless sky, at times when the atmosphere down to the ground was filled with falling ice crystals, the exact forms of which could then be observed. Under such conditions, halos are sometimes produced by artificial lights.[2]

Although it was suggested by Mariotte as early as 1686 that halos are due to the refraction and reflection of light by ice crystals floating in the atmosphere, this explanation was long held in doubt. However, the increasing number of instances (especially in high latitudes) in which the whole atmosphere was filled with minute spiculae and crystals of ice at the same times that sundogs and halos were visible, eventually forced its truth on everyone. As these minute ice crystals fall slowly through the atmosphere, they have a tendency to assume certain definite orientations determined by the resistance of the air; but of course they continually oscillate about the equilibrium positions to a greater or less extent, and if the air is turbulent they lie largely at random. Parallel light incident on a crystal from a given direction will be deviated through refraction or reflection by an amount and in a direction that depend on the form and orientation of the crystal; and because of the multiplicity of crystal faces, different portions of the incident light will leave the crystal in several different directions.

[1] G. C. Simpson, *Quar. Jour. Roy. Met. Soc.*, 38: 291-301, 1912; S. Fujiwhara and H. Nakano, *Jour. Met. Soc. Jap.*, June 1920.
[2] See, e. g., B. W. Currie, Ice Crystals and Halo Phenomena, MON. WEATHER REVIEW 63: 57-58, 1935.

No one particular crystal in a cloud will stay fixed in any given orientation; but at each instant there will always be a multitude of crystals in each of all the different possible orientations. When light from the sun or the moon is incident on the cloud, all the crystals which happen to be simultaneously in any particular one of these orientations will deviate the incident light alike, into certain definite directions, and in any such direction from which the light emerging from the cloud is of sufficient intensity, an observer will perceive a luminous image on the sky, displaced from the position of the source by the angular deviation the ray has undergone; the totality or locus of the virtual images produced by all the different crystal orientations constitutes the halo. Halos produced by refraction are colored, though if faint the colors are not distinguishable—often only a reddish tinge next the sun is discernible; reflection (external, and internal if no refraction occurs) always forms white halos, of course. Any arc that passes through the luminary must be caused by reflection.

The relative intensity of the light which emerges in a given direction from the cloud depends both on the relative number of crystals so oriented as to send light in that particular direction, and on the particular course which has been taken by this light through the crystals. In general, the intensity is sufficiently greater in some directions than in others to result in the appearance of a limited number of distinct mock suns and arcs of circles or other curves. Usually the display is quite simple and comparatively faint—the colored circle of about 22° radius, or a fragment of it, alone or accompanied by a sundog or two; but on rare occasions, an extensive and complex array of brilliant intersecting arcs, circles, and mock suns is produced, many of them strongly colored, of the most fantastic and spectacular appearance (fig. 1).

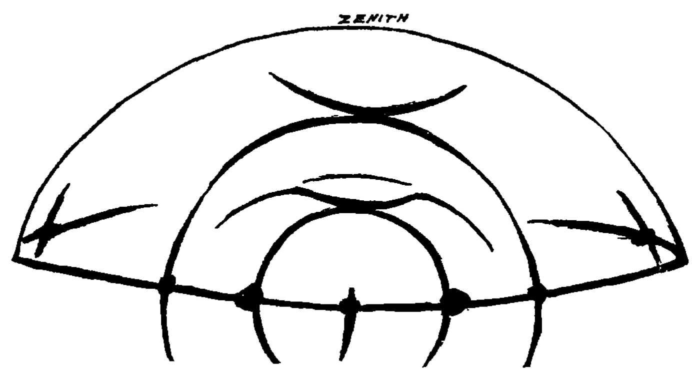

FIGURE 1.—Halo observed at Boulder, Colo., January 10, 1918, showing sun-pillar, parhelic circle, 22° halo, 46° halo, 22° parhelia, 46° parhelia, upper tangent arc of the 22° halo, Parry arc, circumzenithal arc, parhelia of 120°, paranthelic arcs; solar altitude, 20°. Drawn by Edgar W. Woolard. (MON. WEATHER REV., 48: 331, 1920.)

Individual displays differ widely among themselves in respect to the number, forms, brilliance, and coloring of the arcs. The particular arcs that appear, and their brilliance and exact form, depend on the altitude of the luminary above the horizon; on the abundance and predominating geometric forms of the crystals; and on the windiness of the atmosphere. Some of them are quite common and have been known since remote antiquity; others have been seen only a few times. Lunar halos are almost invariably simple, faint, and colored only slightly if at all.

The halos present a fascinating and intricate problem in elementary optics—a problem which in spite of the contributions by Mariotte, Thomas Young, Venturi, Brandes, and Galle had been only very imperfectly worked out prior to the masterly investigations of Bravais about 1845 and of which not all the details have yet been completely solved. Bravais [3] collected all known observations, discussed all the theories of each arc that had been proposed, and so far perfected and completed the theory in a consistent, systematic, and rigorous manner that his monograph immediately became the authority on the subject. His great classic has in the majority of its essential features stood almost intact to the present time and still is a standard source of information. In the case of each of 12 forms Bravais adopted some one of the explanations given by his predecessors, making them more complete and precise where necessary; and, by himself devising new theories for the others, he succeeded in giving what seemed to be satisfactory explanations of nearly all the authentically established forms then on record. He did not wholly escape errors, however, nor entirely clear up all difficulties, and additional observations are continually becoming available. J. M. Pernter was the first who subsequently sought to correct and extend Bravais' work on a comprehensive scale, and more recently important investigations have been made also by Besson, Fujiwhara, Hastings, Humphreys, Visser, Wegener, and others; [4] but many unsolved problems still remain.

The first step in developing a complete and systematic theory of halos is to trace by geometrical optics all the possible courses which may be followed by a ray of light incident upon, and either reflected from or refracted through, an ice crystal of given form. The position, on the sky, of the image due to light incident at a given point on a crystal in a given orientation may then be computed for any particular altitude of the sun or the moon; and, finally the locus of these images corresponding to any given set of different orientations of the crystal may be calculated. This locus represents the geometric form of the optical meteor which will be produced whenever crystals of the given form and with the corresponding orientations are present in the atmosphere but which will be distinguishable only if a sufficiently large proportion of the total light from the luminary be concentrated therein. For this part of the theory of halos, the sole physical principles required are the simple laws of refraction and reflection. The further discussion of observed halos involves the comparison and identification of the observed elements with the theoretical loci and an analysis of the relative frequency and brilliance of different arcs, the particular combinations of arcs that occur from time to time, the details of coloring, etc.

To accomplish the theoretical explanation of a particular observed halo it is necessary (1) to establish the fact of the existence of ice crystals of a certain form in the atmosphere, falling in a certain orientation, and (2) to identify the observed halo with one of the optical meteors which optical theory indicates would be produced by the given crystals in the given orientation. A common method of procedure is to ascertain, by reference to observational records, the forms which actually appear, and then to endeavor to explain them by seeking, in the case of each separately, some certain crystalline form and some particular orientation thereof which would produce that particular appearance. This method has serious limitations, among which is the fact that it is not legitimate to assume arbitrarily the existence, on any given occasion, of particular crystal forms in such numbers and special orientations as to be effective in just the way desired. In fact, the forms and orientations of the crystals responsible for a given halo display might better be deduced from the ensemble of arcs itself by the reverse procedure of comparing the observations with the results of a prior calculation of *all the possible* optical effects which *could* be produced under various conditions by each of the different forms of crystals which observation has shown to exist in the atmosphere from time to time and which are believed to take part in the production of halos.

In any case an essential part of the theoretical investigation of halo phenomena consists of the calculation of the luminous appearances which would be produced on the sky under favorable circumstances by crystals of given forms in given orientations. It would be an invaluable aid in the study of halo phenomena to have available a complete tabulation of all the optical effects that could be produced under various circumstances by each of all the forms of crystals known to be of importance. Such a systematic deduction of all the possible effects, as a method of attack in the theory of halos, was suggested some time ago by Hastings,[5] and has been partially carried out for some cases[6]; but no exhaustive application to all the crystal forms mentioned above has yet been published in detail. The object of the present study is to provide a complete investigation of this type, accompanied by an adequate set of formulas, tables, and diagrams, for the purpose of facilitating the discussion of observations and aiding to perfect the theory.

An immediate satisfactory solution of many of the still remaining problems is difficult or impossible by reason of the insufficient quantity and unreliable character of much of the available observational data and the lack of adequate and accurate measurements. The identification of each element of an observed halo complex with some one of the loci calculated in the geometrical theory is not always an easy problem; there are, e. g., three different theories of the infralateral tangent arcs to the 46° halo, and a set of apparently very careful measurements by Visser (*Kon. Akad. van Wet. te Amst.*, 26, Nos. 9–10, 1923) does not agree with any one of the three. Some of the rarer arcs have as yet been very inadequately observed and measured. Many observers report some of the well-known forms so erroneously that no great confidence can be felt in their descriptions of others, and consequently not all the forms on record can be considered genuine; but among those which apparently are authentic there remain a few whose explanations are unknown or in doubt. Further good observations [7] and additional theoretical investigation both are needed. A definitive solution of the unsolved problems must await the accumulation of more and better data, particularly in the case of the rare and doubtful forms. Meanwhile, a systematic computation by the formulas which the writer has developed should yield all theoretically possible forms; and among these should be found all the halos that ever are actually observed.

[3] A. Bravais. Mémoire sur les Halos et les Phénoménes optiques qui les accompagnent. Journal de l'Ecole Polytechnique, Trente-uniéme Cahier, T. xviii, pp. 1–270. Paris, 1847.

[4] The more important general treatises on the subject are W. J. Humphreys, *Physics of the Air*, 2 ed., New York, 1929; J. M. Pernter und F. M. Exner, *Meteorologische Optik*, 2te aufl., Wien und Leipzig, 1922; Alfred Wegener, Theorie der Haupthalos, *Arch d. Deutschen Seewarte*, Jahrg. 43, Nr. 2, Hamburg, 1926; Rudolf Meyer, *Die Haloerscheinungen*, Hamburg, 1929. There exists a large, but extremely scattered, journal literature. One of Bravais' principal errors, viz, the assumption that a crystal will fall in the orientation which offers the least resistance to the air, is of little importance in the purely geometrical problem with which we shall here be mainly concerned.

[5] Charles S. Hastings, A general theory of halos, MON. WEATHER REV., 48: 322–330, 1920.

[6] See, e. g., P. Putninš, Der Bogen von Parry und andere unechte Berührungsbogen des gewöhnlichen Ringes, *Met. Zeit.*, 51: 321–331, 1934.

[7] See Louis Besson, The different forms of halos and their observation, MON. WEATHER REV., 42: 436–446, 1914. An acquaintance with the general appearance of halo displays, and the ability to recognize the common arcs, are likely to contribute toward an accurate and adequate report. The observer should always state the latitude, longitude, and exact time of the observation; an accurate drawing should be made *during the observation* and should contain only what is *actually seen at one and the same time*. If instruments are available, the altitudes, azimuths, distances from the sun, etc., of conspicuous features should be carefully measured, and the altitude of the sun observed to provide a check for the investigator who uses the report; it should be plainly indicated, in any case where doubt can arise, whether angular readings refer to great circles or to horizontal angles. The coloring and any other notable features of the various elements should be fully described; and the clouds, state of the weather, general appearance of the sky, and description of the development and duration of the display should be given.

INTRODUCTION

A ray incident on one face of an ice crystal and emergent from another face will have undergone ordinary prismatic refraction, in which the angle between the two faces is the refracting angle. An application of the elementary law of refraction, $\sin i = \mu \sin r$, at both the point of incidence and the point of emergence leads to trigonometric relations (given in detail later in this paper) from which the position of the image *relative to that of the source* may easily be computed; the position, *relative to the horizon*, of the image formed by light incident on a particular face of an ice crystal of specified form in a given orientation is then readily found for any given altitude of the sun or moon by further trigonometric formulas. Similarly for images formed by reflection, or by a combination of both refraction and internal reflection. The locus of such of these images as correspond to any given set of different crystal orientations may then be obtained by appropriately varying in the formulas the parameters which specify the orientation of the crystal; the effects are always symmetrical about the solar or lunar meridian.

Undoubtedly there are always some crystals in each of all conceivable orientations in a cloud; but the locus of the images produced by the crystals in any particular set of these orientations will not be distinguishable unless sufficiently bright (both absolutely and relatively). Now, there are two factors, either of which will result in a relative concentration of the available light into the images produced by certain particular orientations: Crystals so oriented that the deviation by one of the refracting angles is a minimum will produce relatively bright images, because in the direction of minimum deviation there is a narrow and concentrated beam, while in other directions the light is diffuse and faint; the greatest intensity is at the minimum minimorum. Again, if there be a larger proportion of the crystals similarly oriented in some orientations than in others, the images produced by the former will be relatively the brighter. At oblique angles of incidence, much light is lost by external reflection, and the corresponding refraction halo will be faint. In general, a reflection must be a total internal one to result in a conspicuous effect.

Ordinarily, the only loci that actually become visible are produced by the simultaneous operation of *both* a predominant orientation and either a minimum deviation or a total reflection, but there are important exceptions. If conditions are such that the resistance of the air is able to dominate the orientation of the falling crystals to a sufficient degree, so that a large enough proportion of the crystals lie in the neighborhood of certain equilibrium positions, then the locus given by refraction at these equilibrium positions may appear even when the deviation is not a minimum; on the other hand, even when the crystals lie completely at random—equally distributed among all conceivable orientations—the concentration of light at minimum deviation may be sufficient for the appearance of the corresponding locus even though there are no more crystals in the necessary orientation than in any other orientation. Usually, however, it is only when a relatively large proportion of the crystals lie near particular orientations in which also the deviation is a minimum that the relative concentration of the available light into a particular locus is great enough to produce a distinct halo; and with few exceptions, when minimum deviation alone does give rise to a halo, it is the minimum minimorum which is necessary, while the production of a halo by a predominance of certain orientations alone requires the restricting influence to be effective enough to deprive a sufficient proportion of the crystals of *two* of their three degrees of rotational freedom.

It will be of interest to describe briefly a few illustrative examples of arcs produced in each of the above general ways:

When the crystals in a cloud lie completely at random—no more of them in any one orientation than in any other—each of the refracting angles will produce images in all directions from the source of light, and at all distances, beginning at the minimum minimorum, up to the maximum possible deviation; the result, when bright enough to be observed, is a circular halo around the luminary, at the distance corresponding to minimum minimorum. The 22° halo is produced in this way by the 60° refracting angles. The inner edge is sharp, and the sky within is comparatively dark; the outer edge is diffuse, the sky being illuminated with a white glare to some distance beyond the halo. Even when the crystals do not lie completely at random, there often are enough crystals in each of all orientations for this halo or a portion of it to appear; the 22° halo is exceedingly common, but it is seldom noticed by the casual observer, because usually it is quite faint, and often fragmentary and ephemeral. Similarly, the 46° halo is produced by 90° angles; and certain very rare halos of unusual radii by the angles in pyramidal crystals of various forms.[8] It is to the 22° ring that the term "halo" generically applies; but by extension it has come to be applied also to the other optical meteors of analogous origin.

Since the resistance of the air tends to restrict the freedom of motion of the crystals, they will not in general be distributed completely at random; but to a greater or less extent, depending on circumstances, a larger proportion of the crystals will lie in certain orientations than in others. In particular, hexagonal columns (with plane bases) tend to fall with the principal axis (i. e., the longer axis) horizontal, and are thus largely deprived of one degree of rotational freedom; to a lesser extent, they also tend either to keep one pair of lateral faces horizontal or else a diagonal of the hexagonal cross section vertical, and thus to be deprived of a second degree of freedom. We may therefore expect that in a cloud in which this type of crystal is present, a large proportion of the crystals will have their principal axes in or near a horizontal position, and, to a lesser extent, these will in turn tend to be in or near the equilibrium positions just mentioned: The crystals may rotate freely about a vertical axis, so that the principal axes will be distributed at random in azimuth; and they may also rotate about the principal axis, but will not be distributed completely at random in this respect.

As an example, consider any one of the 60° refracting angles in a crystal when the axis is constrained to remain horizontal. The refracting edge will be horizontal and the principal plane vertical. To compute the image produced, at any altitude of the sun or moon, when the refracting edge is in any azimuth and the faces of the angle at any inclination to the horizontal, the orientation of the face of incidence may conveniently be specified by the inclination of the normal to the horizontal, and the position of the axis by the azimuth θ of the normal, measured from the solar vertical; the position of the image is given by the trigonometric calculation of its azimuth and altitude, or its distance and position angle from the luminary.

To calculate the form of the optical meteors which will be produced when the crystals are deprived of only *one*

[8] See W. J. Humphreys, Physics of the Air, 2 ed., pp. 516–517; and MON. WEATH. REV. 50: 535–536, 1922; 51: 255–256, 1923; 61: 328–329, 1933.

degree of freedom, and hence rotate about both the principal axis and a vertical axis, we need consider only those angles so oriented as to give minimum deviation. The corresponding images are obtained by assigning a series of arbitrary values to θ, and giving the deviation its minimum value for each one, in the appropriate trigonometrical formulas; the resulting loci are known as the tangent arcs to the 22° halo, and are examples of arcs produced by the combined effects of minimum deviation (not minimum *minimorum*) and predominant orientation.

To calculate the halos which will be produced by crystals deprived of *two* degrees of freedom, and hence rotating only about a vertical axis, we need consider only the two equilibrium positions. The rare Parry arc above the 22° halo is due to light which is incident on the top faces of crystals which have two lateral faces horizontal; this arc is an example of a halo produced by a predominant orientation alone. A more common example is the circumzenithal arc, produced by 90° refracting angles with one face horizontal and the other vertical; in this case the general formulas show that the circumzenithal arc is simply a circle parallel to the horizon. It often occurs alone, and is the most brilliantly colored of all halos; in spite of its position in the sky it frequently is reported as a rainbow. The ordinary 22° sundogs are likewise due to crystals which have only one degree of freedom, but the principal plane of the refracting angle (60°) is horizontal in this case; it is to be noted that the sundogs are *outside* the corresponding halo—except when the luminary is on the horizon. The visible portion of the locus is ordinarily that at and near minimum deviation but is not at the minimum minimorum.

Reflection from vertical crystal faces rotating about a vertical axis produces the white parhelic circle, passing through the sun parallel to the horizon. Finally, an interesting example in which total internal reflection is involved may be mentioned: Light which at a high altitude of the sun falls upon the two upper sloping faces of hexagonal columnar crystals that have two lateral faces horizontal, and emerges from the lower horizontal face after internal reflection by a vertical plane base, the crystals being randomly oriented in azimuth, produces the so-called Lower Oblique Arcs of the Anthelion, which are among the rarely observed phenomena.[9]

The following sections [10] will present a systematic arrangement of formulas from which the various arcs mentioned above, as well as all others that can be produced in the different possible cases, may be computed.

[9] Edgar W. Woolard, On the Lower Oblique Arcs of the Anthelion, MON. WEATHER REV., 50: 537–539, 1922.
[10] To be published in later issues of the REVIEW.

WIND AND MINIMUM TEMPERATURE IN THE REDLANDS, CALIFORNIA, FRUIT-FROST DISTRICT

By JACK JANOFSKY

[Weather Bureau, Pomona, Calif., October 1936]

Fruit-frost work on the Pacific coast began in 1917. Starting with 2 widely separated stations, the service has since grown to include 18 winter and spring districts. The forecasting difficulties encountered in two different districts are never wholly alike, varying with the season and geographical location. When positive signs point to the development of ocean cloudiness, radiation fog, or wind during the night, no major forecasting difficulties are presented; but when indications are less definite, forecasting minimum temperatures becomes exceedingly difficult.

In the Redlands, Calif. district, wind is the important consideration; because no other phenomenon can there influence temperature forecasts so readily, it is especially deserving of critical treatment. The paper which follows presents a study of wind in the Redlands fruit-frost district, but the methods used should yield consistent results elsewhere.

The Redlands fruit-frost district lies in the northern extremity of the Great Valley of southern California, one of the richest citrus-growing centers in the world. Resembling a right triangle in shape, with the San Bernardino Mountain Range on the north as hypotenuse and the foothills of the San Jacinto Mountain Range on the south as base, the district is roughly 110 square miles in area. The foothill ranges converge in the east, with Crafton Hills, 3,540 feet high, closing the valley; but to the right and left rear are the San Gorgonia and San Jacinto peaks approximately 11,000 feet above sea level. The district opens in the west and merges 20 miles away with the flatter Great Valley to include the communities of Fontana and Bloomington as the western limits. The smooth valley floor slopes gently from the foothill areas and drains radially to the point of lowest elevation 7 miles southeast of Fontana, near Colton, about 950 feet above sea level. Elevation contours run in a general north-south direction in the east near Redlands, and an east-west direction near Fontana. A representative slope for the valley floor would be 75 feet per mile, but on approaching the foothills the slope gradient steepens rapidly.

Despite the small size of the district, forecasting minimum temperatures is complicated by a formidable wind problem. Winds, other than the usual canyon breezes, are generated and give relative immunity to frost at exposed places, whenever a strong area of high barometric pressure moves inland from off the northern California coast or develops over the plateau region. Fontana, which lies just southwest of a large mountain pass, is periodically subject to winds of this nature.

An introduction to the Redlands district would not be complete unless accompanied by a more detailed description of Cajon Pass. The meteorological importance of this topographical landmark is due to the prominent control it exerts over southern California weather; more specifically, to understand the main forecasting problem in the Redlands district, it is first necessary to understand the mechanics of the canyon winds. In his paper [1] "Desert Wind in Southern California", Floyd D. Young deals with the subject thoroughly:

> The air moving outward from the plateau high-pressure area is blocked on the south by the San Gabriel and San Bernardino Mountains. Wherever there is a break in these southern chains, such as Cajon Pass, the desert air streams through it and out onto the Great Valley of southern California. If the pressure difference between Nevada and southern California is only moderate, the desert winds usually are confined to rather narrow belts extending from the mouths of the passes to the ocean by the lowest and least obstructed route. * * *
>
> Cajon Pass lies between the San Gabriel and San Bernardino Mountain Ranges, extending roughly north and south, turning toward the southeast near its southern extremity. It is a V-shaped notch about 17 miles long and quite narrow, extending from the Mojave Desert on the north to the Great Valley of southern California on the south. The slope from the summit of the pass northeastward is gradual, the summit being only slightly higher than the general level of the desert. The fall from the summit toward the

[1] MONTHLY WEATHER REVIEW, 59: 380-381, October 1931.